

# Mathematical models for immune cell growth and differentiation

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An immune system protects against diseases by detecting and eliminating antigens, including viruses, tumors and so on. Despite of its protective activity, the immune system sometimes incorrectly attacks self-tissue (autoimmunity) or over-reacts to harmless environmental substances (allergy). In general, these disorders are a consequence of dynamical interactions among immune cells and pathogens. Therefore it is important to understand the dynamics of an immunological network for prediction and control of immune responses.

From a information-theoretic point of view, host protection machinery against pathogen of the immune system is interpreted as a kind of information processing mediated by a network composed of functionally distinct immune cells. Although some information-theoretic aspects of the immune system have been investigated, it remains unsolved to make a connection between theoretical and experimental studies.

Today I would like to introduce a theoretical study of the immune system inspired by experimental studies on the quantitative measurement of immune cell growth and differentiation. We construct a mathematical model which describes division/death processes of immune cells. It is shown that a modified birth-death (stochastic) process with senescence-accelerated cell death rate well describes in vitro cell proliferation measurement (Hawkins et al, PNAS 2009). In the following, the model is further extended to include differentiation processes of naive CD4 T cells into either effector Th1 or Th2 subsets. It is shown that heterogeneity among naive CD4 T cells in the amount of gene expression in response to antigenic stimulation can be an important factor to determine the balance of the Th1/Th2 ratio.